# The OptIPuter: Global OptIPortals on Lambdas

**Dr. Thomas A. DeFanti**
**Research Scientist**
**California Institute for Telecommunications and Information Technology**
**University of California, San Diego**

**Distinguished Professor Emeritus of Computer Science**
**University of Illinois at Chicago**

**Director**
**Electronic Visualization Laboratory**
**University of Illinois at Chicago**

**Principal Investigator, TransLight/StarLight**

# First, A Vision for the Next Decade: Gigapixels @ Terabits/sec


**1 GigaPixel x 3 Bytes/pixel x 8 bits/byte x 30 frames/sec ~ 1 Terabit/sec!**

STARLIGHT TRANS LIGHT

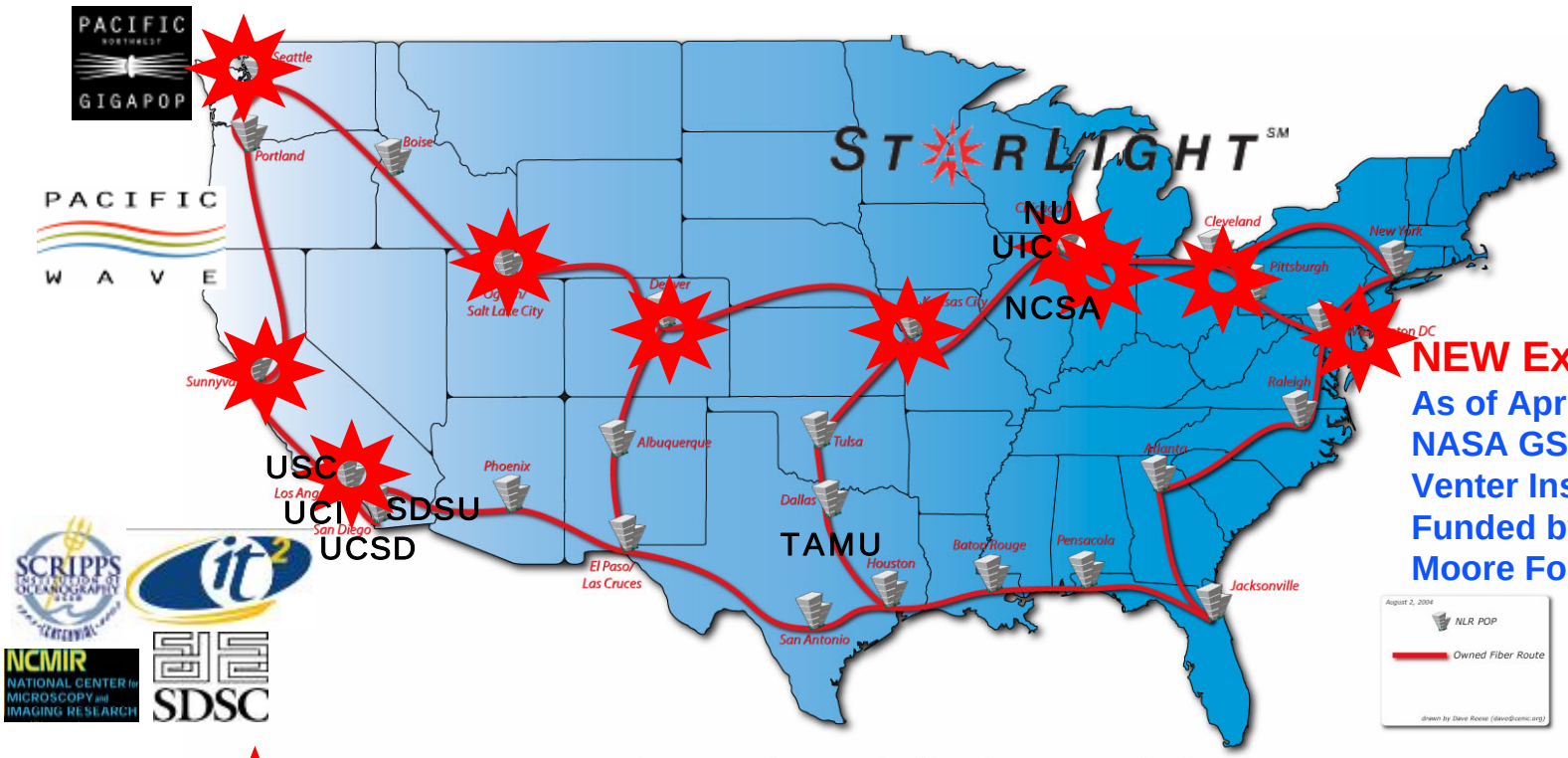
glif

**Source: Jason Leigh, EVL**

it2

evl

# Since 2004: The OptIPuter's 10GE CAVEwave on the National LambdaRail




**NEW Extension!**

**As of April 1, 2006:**
**NASA GSFC**
**Venter Institute**
**Funded by the Moore Foundation**

**CAVEwave™ is the University of Illinois at Chicago (UIC) Electronic Visualization Laboratory's very own 10 Gigabit wavelength on the NLR infrastructure, connected to the University of Washington in Seattle and UCSD in San Diego, enabling OptIPuter experiments.**

www.evl.uic.edu

# The CAVEwave links the California Institute for Telecommunications and Information Technology (Calit2)


- Virtual Reality, 4K Digital Cinema, HDTV
- Nanotech, Chips, Radio, Photonics, Grid Software, Data, Applications
- Over 1000 Researchers in Two Buildings
- Linked via Dedicated Optical Networks
- For International Conferences and Testbeds

**Preparing for an World in Which Distance Has Been Eliminated…**


StarLight

TransLight

glif

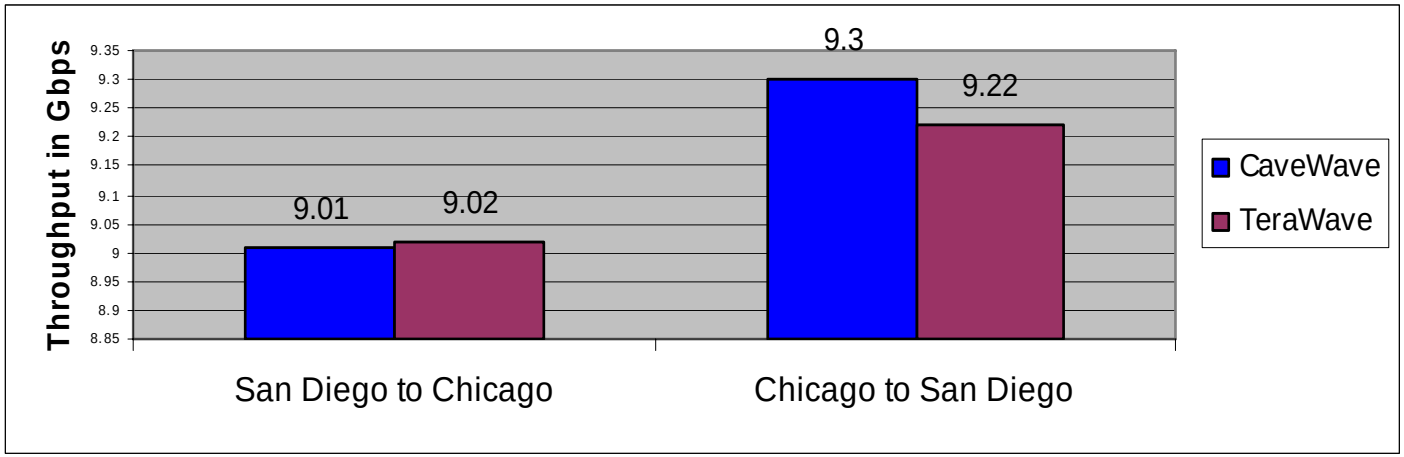
# And the Electronic Visualization Laboratory at UIC

- EVL established in 1973

- EVL is the development laboratory for eruptive technology research and deployment for Calit2 and many other laboratories

STARLIGHT TRANSLIGHT glif it2 evl

# 9Gb/s Disk-to-Disk Performance with LambdaStream between EVL and Calit2




**CAVEWave**:
20 senders to 20 receivers (point to point )

Effective Throughput = 9.01 Gbps
*(San Diego to Chicago)*
*450.5 Mbps disk to disk transfer per stream*

Effective Throughput = 9.30 Gbps
*(Chicago to San Diego)*
*465 Mbps disk to disk transfer per stream*

**TeraGrid**:
20 senders to 20 receivers (point to point )

Effective Throughput = 9.02 Gbps
*(San Diego to Chicago)*
*451 Mbps disk to disk transfer per stream*

Effective Throughput = 9.22 Gbps
*(Chicago to San Diego)*
*461 Mbps disk to disk transfer per stream*

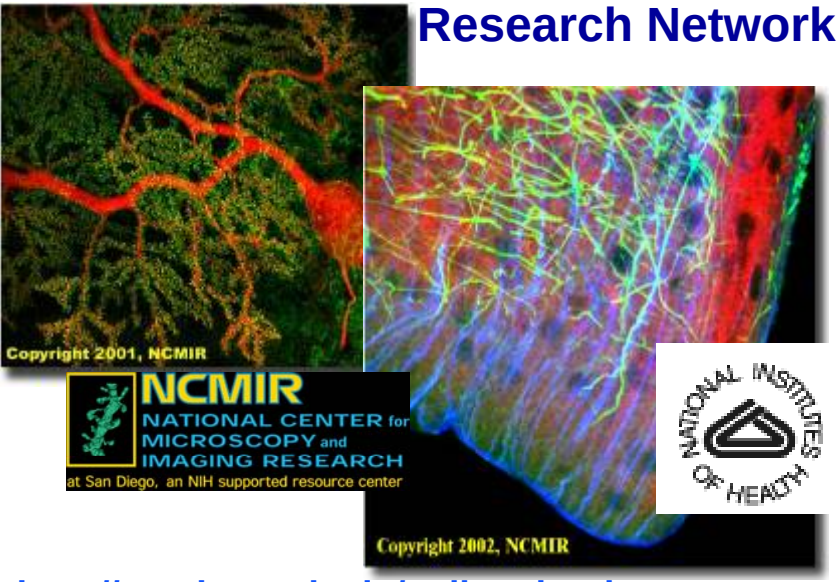
*Dataset: 220GB Satellite Imagery of Chicago courtesy USGS.*
*Each file is 5000 x 5000 RGB image with a size of 75MB i.e ~ 3000 files*

Source: Venkatram Vishwanath, UIC EVL

# How We Get to Gigapixels over Terabits: The OptIPuter Project

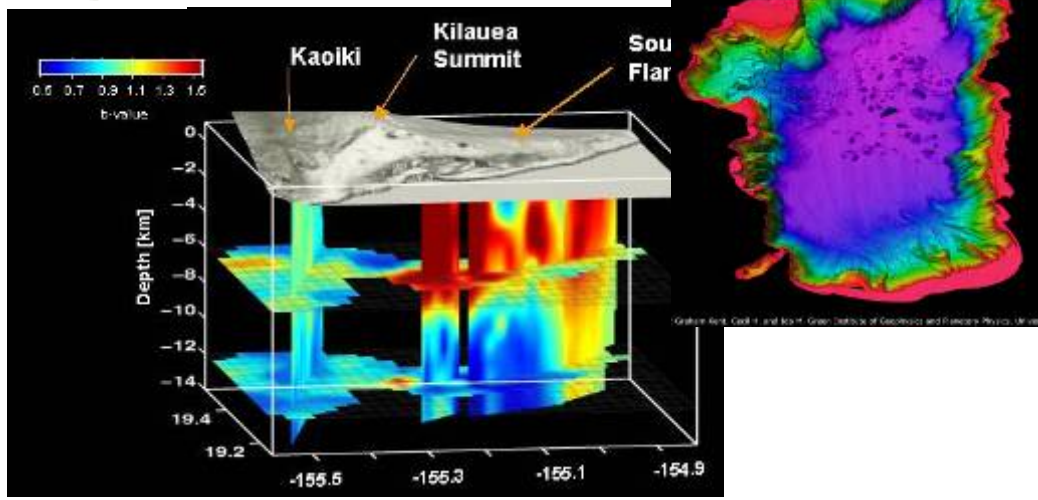
- An NSF-funded ITR award to develop technology for the real-time collaboration and visualization of very-large, time-varying volumetric datasets for the earth sciences and the biosciences; now extending to metagenomics and digital cinema applications through private sector funding
- OptIPuter is our model of computing in which ultra-high-speed networks form the backplane of a global computer thereby removing bandwidth as an obstacle in data-intensive sciences
- UCSD, UIC, UCI, USC, SDSU, NU, UIUC/NCSA, TAMU, UvA, SARA, CANARIE, CRC, AIST, KISTI

## NIH Biomedical Informatics Research Network




http://ncmir.ucsd.edu/gallery.html

## NSF EarthScope and ORION




siovizcenter.ucsd.edu/library/gallery/shoot1/index.shtml

STARLIGHT TRANSLIGHT

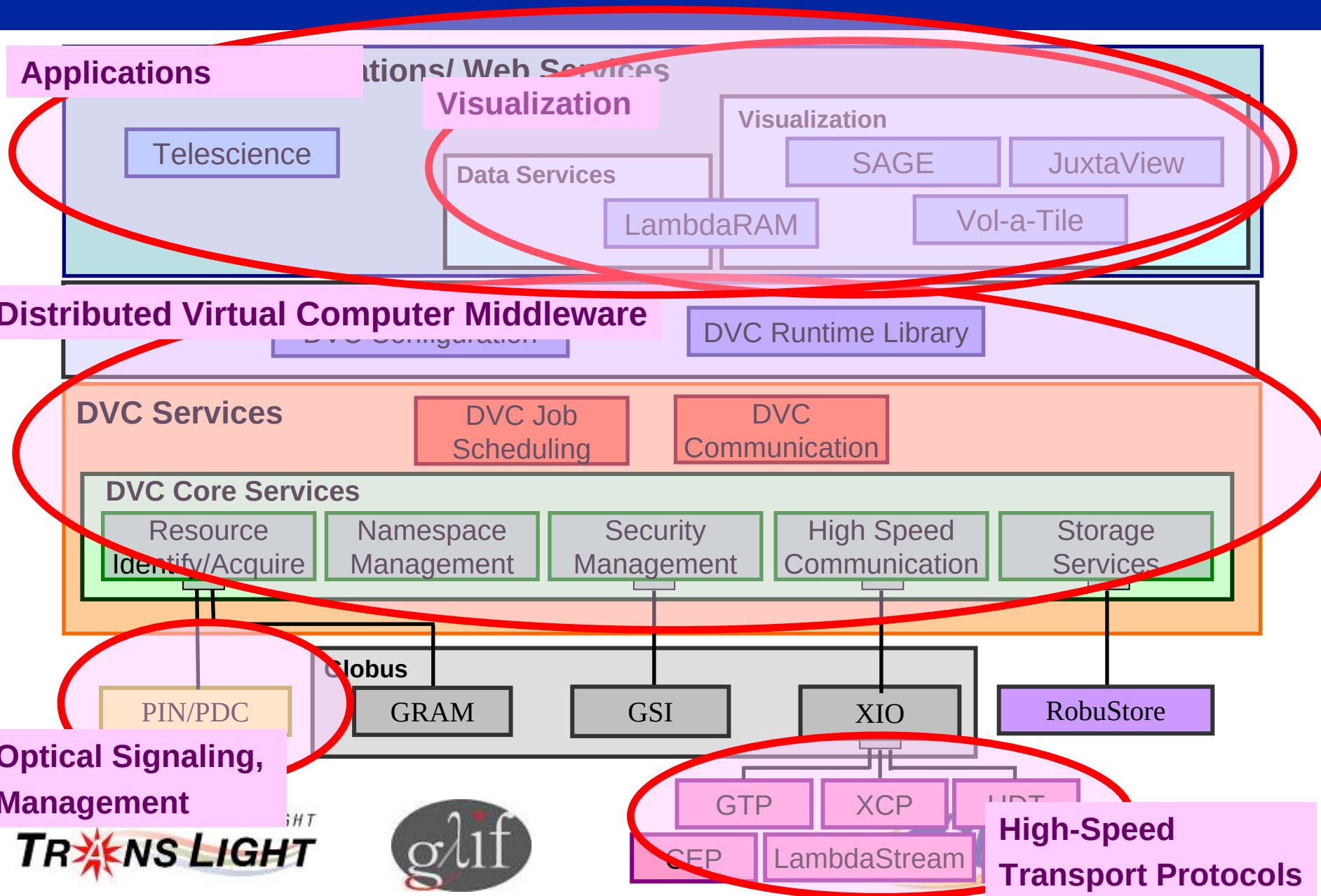
glif

www.optiputer.net

it2

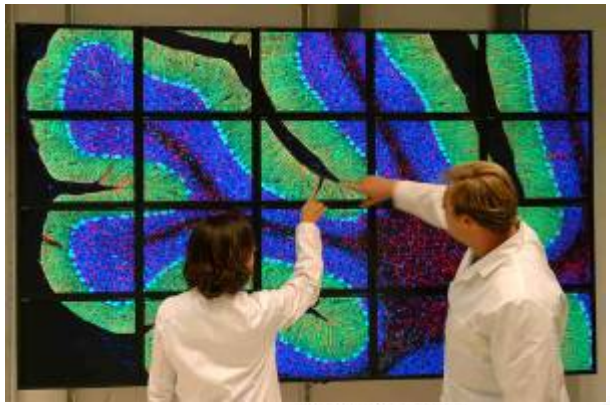
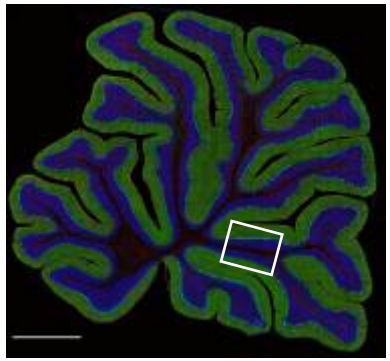
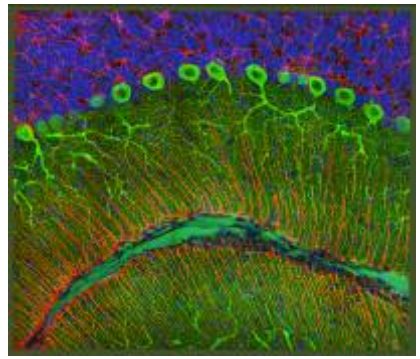
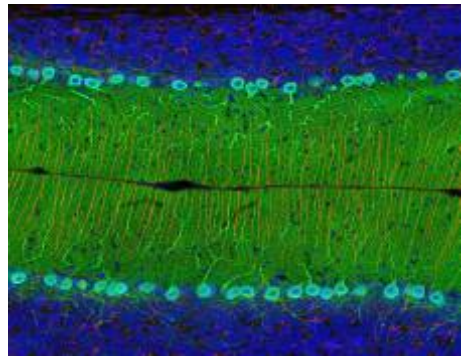
evl

# OptIPuter System Software Architecture



# The OptIPortal
# Enabling Users to See Gigabyte Data Objects

- 100s of megapixel 2D images & 3D objects are becoming common
- Usable interactive analysis and visualization of data objects requires deterministic, not “best effort” campus networks
  - Guaranteed Bandwidth (data movement, security)
  - Guaranteed Latency (visualization/collaboration, data analysis)
  - Guaranteed Availability (remote instruments, production schedules)
- Interactive analysis and visualization of high-res data objects requires:
  - Scalable visualization displays (OptIPortals)
  - Scalable adaptive graphics environments (SAGE)

STARLIGHT TRANSLIGHT

glif

NCMIR NATIONAL CENTER for MICROSCOPY and IMAGING RESEARCH at San Diego, an NIH supported resource center

it²

evl

# OptIPortals are 40-200 Megapixel Collaboration Walls with 5-60 Terabytes Storage Connected by Lightpaths


**Price: $1K/Megapixel (10 pixels/JPY) (plus storage and network as needed)**

STARLIGHT TRANSLIGHT

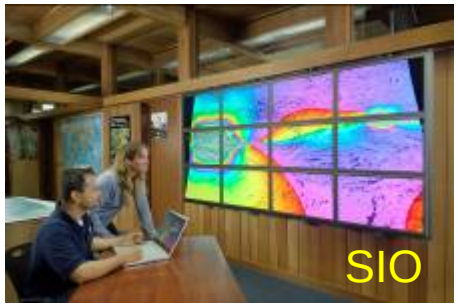
glif

**Source: Luc Renambot, EVL**

it²

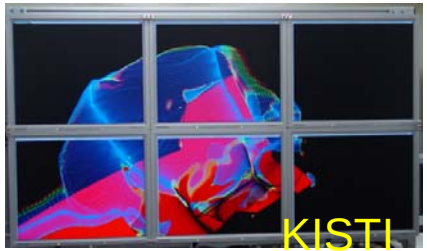
evl

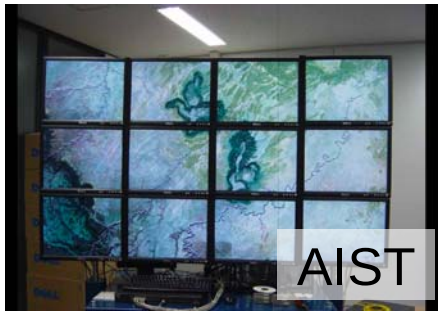
# Some Important OptIPuter OptIPortal Sites



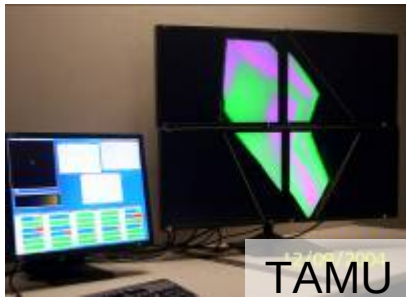












STARLIGHT
TRANS LIGHT

glif

**Source: Luc Renambot, EVL**

it2

evl

# SAGE OptIPortal Software: 10 Wireless Laptop Users All Pushing Their Desktops to the EVL OptIPortal--Goal is a Distributed Gigapixel in 2007

STARLIGHT TRANSLIGHT

glif

Source: Luc Renambot, EVL

it²

evl

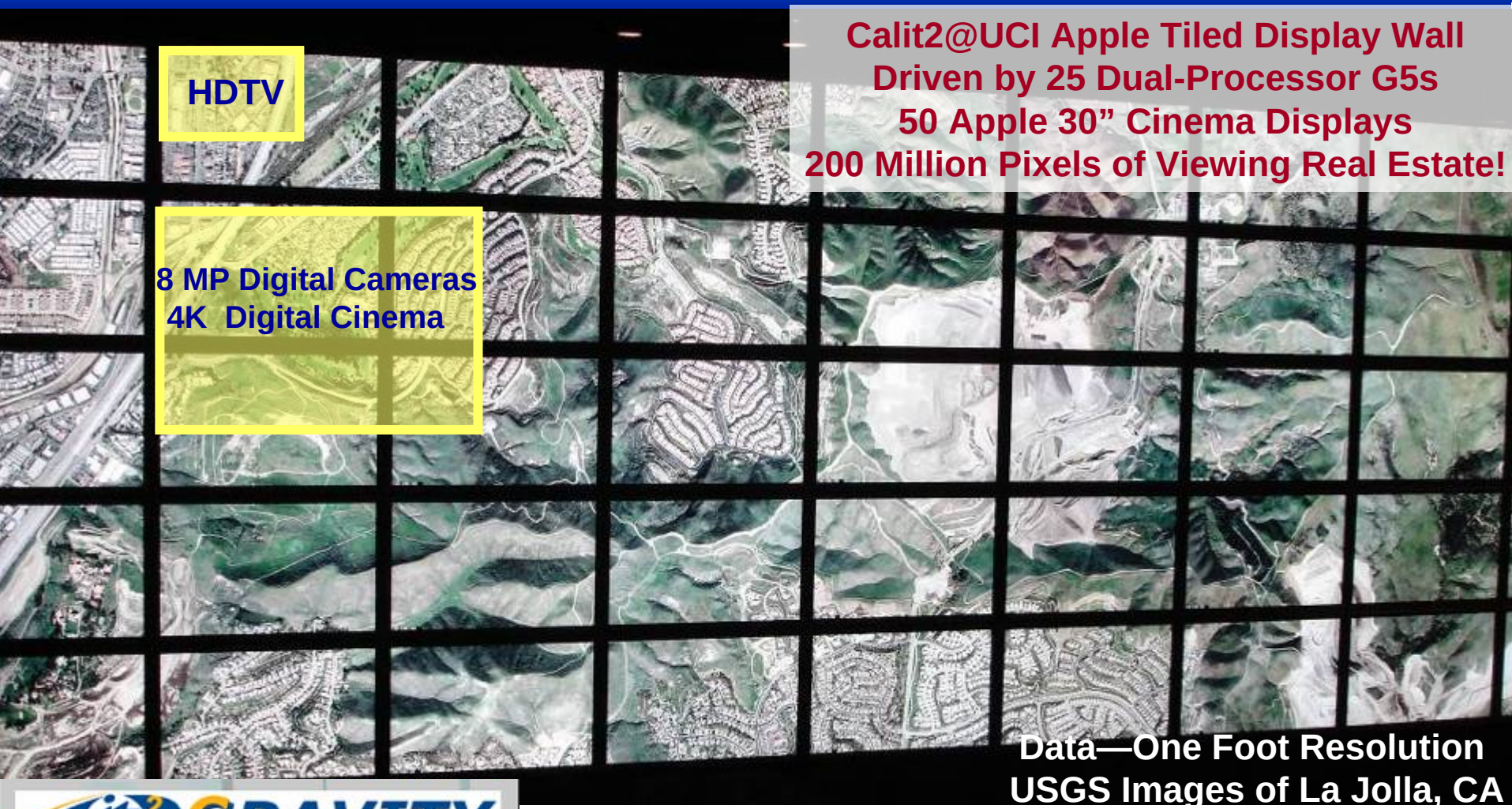
# SAGE Also Merges Data with HDTV and 4K Streams

Source: David Lee, NCMIR, UCSD

# Emergency Response Prototype OptIPortal: Waterproof, Portable, Wireless


Source: Calit2 WIISARD, RESCUE, RESPONSPHERE MMST Drill August 22, 2006

# Calit2 @ UC Irvine Has the Largest Known OptIPortal—the HIPerWall




Source: Falko Kuester, Calit2 UCI

# Next: The OptIPortal in 3D, No Glasses:
## EVL's Varrier High-Resolution VR Autostereo Display

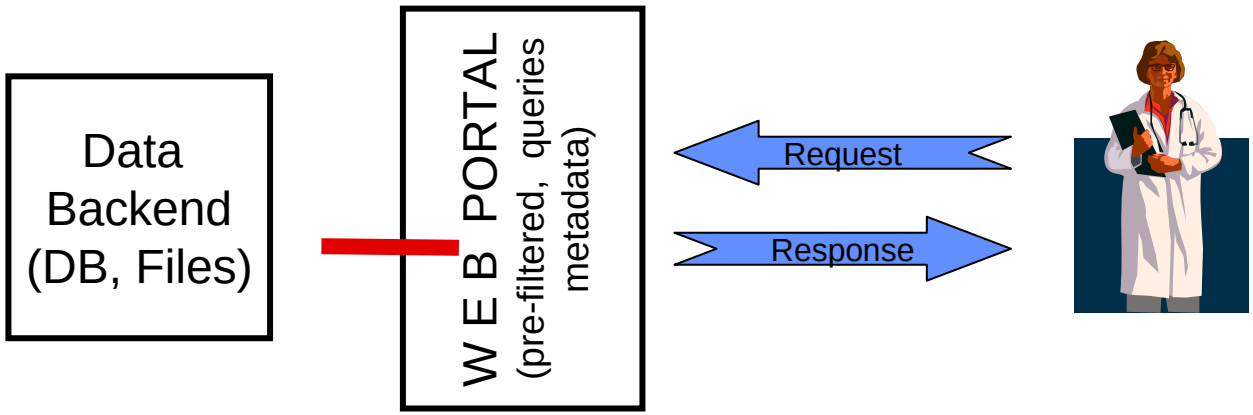
Source: Dan Sandin, Tom Peterka, Todd Margolis, EVL

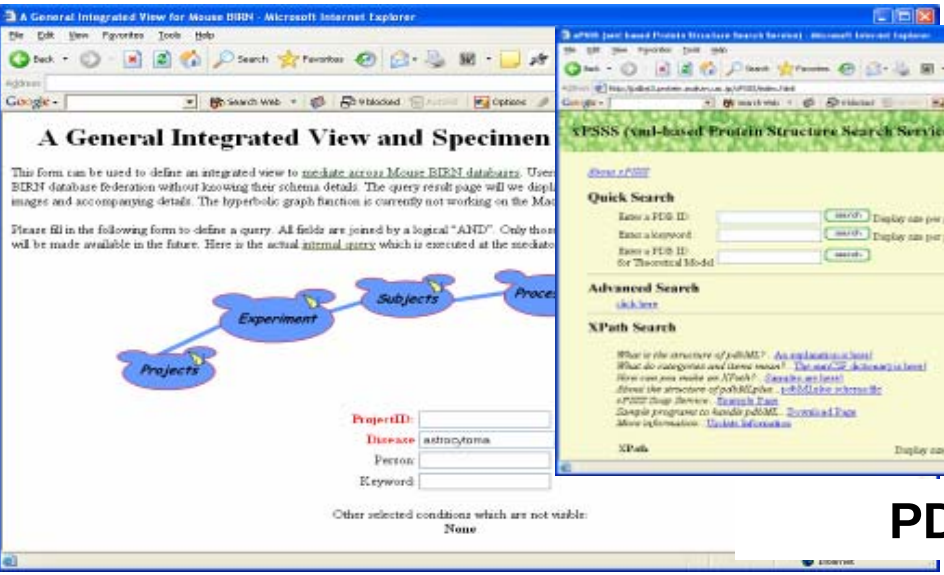
# Collaboration is the OptIPuter's Main Contribution

- **Many of the highest performance e-science applications involve national and international collaboration.**
- **This was NSF's main goal of building Chicago's STAR TAP (ATM) in 1996 and StarLight (GE and 10GE) in 2001.**
- **Colleagues in Japan, in America, Canada, Netherlands, Korea, China, UK, Czech Republic and elsewhere, agreed in 2003 to form a global initiative to create a photonic network testbed for the common good.**
- **This, of course, is *GLIF*, the Global Lambda Integrated Facility.**
- **The OptIPuter depends on GLIF and its GOLEs**

STARLIGHT TRANSLIGHT glif it² evl

# The OptIPuter Jumps Beyond Traditional Web-Accessible Databases

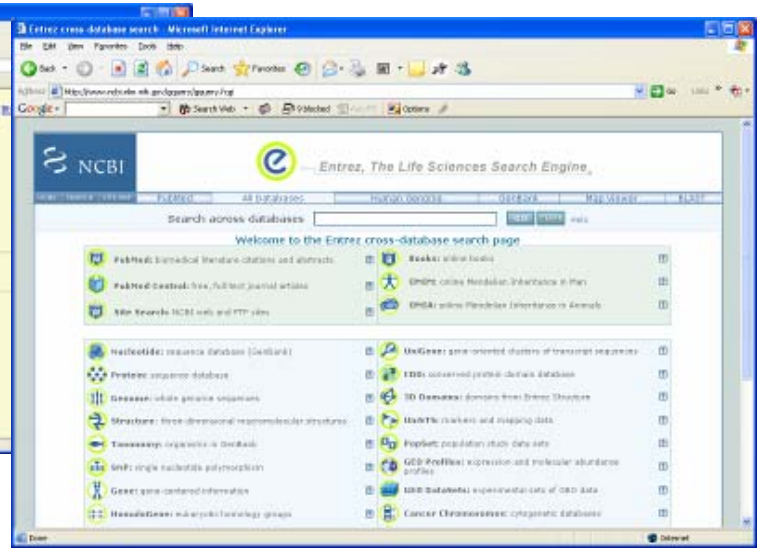



BIRN




PDB




NCBI Genbank

STARLIGHT TRANSLIGHT

glif

Source: Phil Papadopoulos, SDSC, Calit2

it2

evl

# OptIPuter's Direct Access Core Architecture Will Create Next Generation Metagenomics Server

**Sargasso Sea Data**

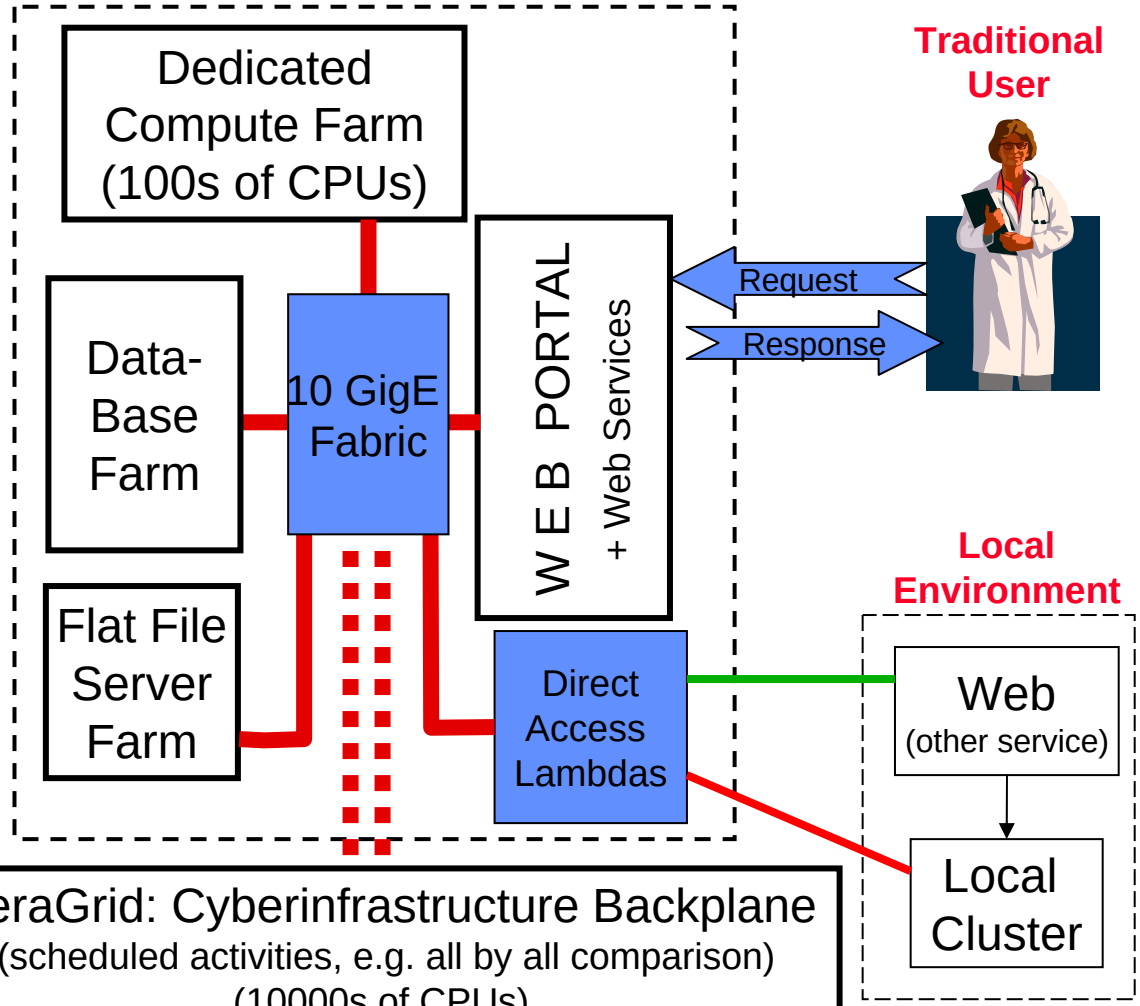
**Sorcerer II Expedition (GOS)**

**JGI Community Sequencing Project**

**Moore Marine Microbial Project**

**NASA Goddard Satellite Data**

**Community Microbial Metagenomics Data**




Source: Phil Papadopoulos, SDSC, Calit2

# CAMERA: Community Cyberinfrastructure for Advanced Marine Microbial Ecology Research and Analysis

## National LambdaRail
## Direct Connect
## Computation and Storage Complex

Funded by: Gordon and Betty Moore Foundation

Joint Partnership of:

PI Larry Smarr

# Marine Genome Sequencing Project
# Measuring the Genetic Diversity of Ocean Microbes






MARINE MICROBIOLOGY INITIATIVE

Gordon and Betty MOORE FOUNDATION

J. Craig Venter INSTITUTE

**CAMERA will include**
**All Sorcerer II Metagenomic Data**

STARLIGHT TRANS LIGHT

glif

it²

evl

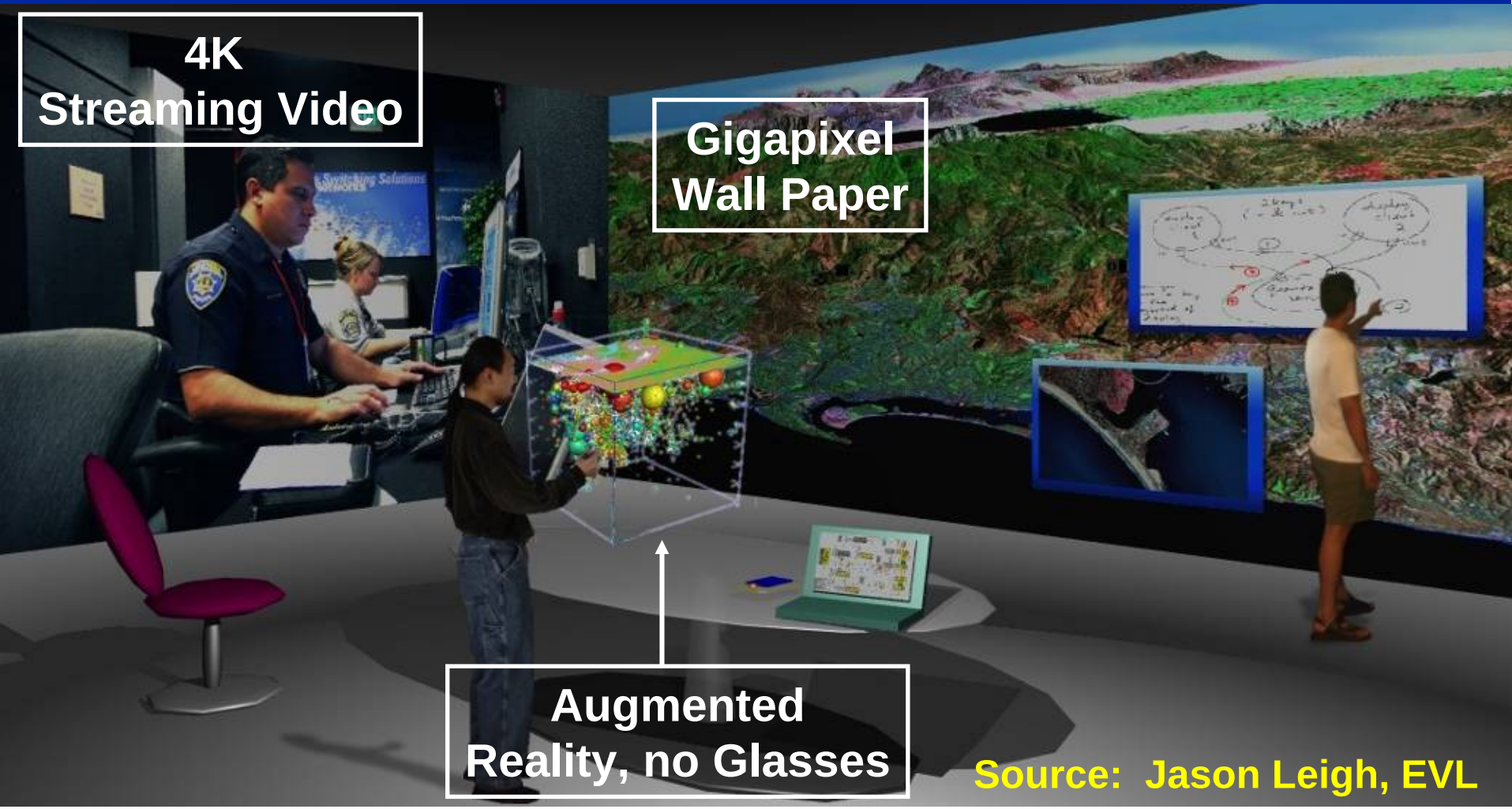
# Conclusion: OptIPuter Applications Illustrate Need for Optical Networks

- Interactive collaboration using video (SD, HD, SHD) and/or VR
  - Low latency streaming (real-time use)
  - High data rates
  - Lossy protocols OK
  - Multi-channel, multi-cast
- Interactive Biomedical Imaging
  - Very high resolution 2D (tens to hundreds of megapixels)
  - Volume visualizations (billions of zones in 3D)
- Interactive Geoscience Imaging
  - Very high resolution 2D (tens to hundreds of megapixels)
  - Volume visualizations (billions of zones in 3D)
- Digital cinema
  - Large data sets—4K is 250Mb/s compressed, up to 14Gb/s uncompressed
  - Security
- Metagenomics
  - Large computing
  - Large data sets

# Conclusions after 4 Years of OptIPuter R&D

- **OptIPuter technologies work with effort, but getting easier to configure, more affordable, and quite replicable**
- **OptIPuter applications benefit from deterministic networks:**
  - **Known and knowable bandwidth**
  - **Known and knowable latency**
  - **Availability of entire 10G lightpaths when necessary**
- **OptIPuter partner activities are training the next generation of network engineers, middleware, and application experts**
- **High-resolution video and audio are extremely demanding**
- **Scalability and commercialization remain challenging!**

# Conclusion: OptIPortal Gigapixel Terabit/sec Networked Data-Intensive Displays are Coming!




**1 GigaPixel x 3 Bytes/pixel x 8 bits/byte x 30 frames/sec ~ 1 Terabit/sec!**

STARLIGHT TRANS LIGHT glif it2 evl

# Thank You Very Much!

- **OptIPuter/OptIPortal research, education, and outreach efforts are made possible, in major part, by funding from:**
  - US National Science Foundation (NSF) awards ANI-0225642, EIA-0115809, and SCI-0441094
  - State of Illinois I-WIRE Program, and major UIC cost sharing
  - State of California and UCSD Calit2
  - Many corporate friends and partners
  - Gordon and Betty Moore Foundation
- **Argonne National Laboratory and Northwestern University for StarLight and I-WIRE networking and management**

# For More Information

- www.glif.is
- www.startap.net
- www.evl.uic.edu
- www.calit2.edu
- www.nlr.net